Condyle displacement associated with premolar extraction and nonextraction orthodontic treatment of Class I malocclusion

Paul Major, DDS, MSc, MRCD(c),[a] Lorne Kamelchuk, DDS, MSc,[b]
Brian Nebbe, BDS, MDent, FFD(SA) Ortho,[b] Grace Petrikowski, DDS, MSc, MRCD(c),[c]
and Kenneth Glover, DDS, MSc, MRCD(c)[d]
Edmonton, Alberta, Canada

This study assessed condyle position change with premolar extraction and nonextraction orthodontic treatment in Class I malocclusions. Axially corrected pretreatment and posttreatment tomograms were obtained in 22 extraction and 13 nonextraction cases. Tomographic images were randomized and blinded for joint space measurement. A total of 27 linear anterior, superior, and posterior joint spaces were obtained from each tomogram and averaged. Comparisons of pretreatment and posttreatment joint spaces between groups were done by *t* test (pool variance estimate) with $p < 0.05$. Left and right anterior joint spaces were significantly increased during orthodontic treatment of the nonextraction group. No other significant changes in condyle position were determined in either group. There were no significant correlations between mean joint space changes with length of Class II elastic wear. There was no significant difference in condyle position change with extraction space closure using closing arch wires compared with alastic chain. (Am J Orthod Dentofac Orthop 1997;112:435-40.)

Premolar extraction to facilitate orthodontic treatment is a common but controversial procedure. O'Connor[1] reported that extraction rate has declined from a mean of 38% in 1988 to 29% in 1992. Claims that extraction of teeth may be deleterious to the health of the temporomandibular joint (or medicolegal implications thereof) had a considerable influence on the decline, with 26% of orthodontists being influenced, to some extent, because of this factor.[1] The majority of respondents believe that a routine link between premolar extraction and subsequent development of temporomandibular disorders (TMDs) does not exist, but believe that such a link may occasionally exist. In an extensive review of the literature up to 1988, Reynders[2] found that publications supporting a causative link were either viewpoint articles or case reports that have little or no real value beyond generating new ideas and hypotheses. Retrospective sample studies[3-8] and longitudinal sample studies[9-11] have consistently failed to demonstrate a causative link between orthodontic treatment (including premolar extraction) and TMD.

Although scientific literature does not support a causative relationship between orthodontics and TMD, no orthodontic treatment should be undertaken in isolation without considering its possible effect on the temporomandibular joint. To have a direct effect on the anatomy of the temporomandibular joint, there would need to be a change in anatomic relationships, direction of loading, or magnitude of loading. Opponents of premolar extraction have claimed that extraction results in a decrease in vertical dimension of occlusion. As the mandible is allowed to overclose, the muscles are foreshortened, resulting in TMD.[12,13] Although widely stated, no controlled published studies support this hypothesis. Staggers[14] compared vertical dimension changes in 45 Class I nonextraction and 38 Class I premolar extraction cases. On average, orthodontic treatment produced a net increase in vertical dimension with no significant difference between extraction and nonextraction groups.

A second hypothesis was that premolar extraction with incisor retraction leads to posterior condyle displacement.[12,15] The concept that posterior condyle position leads to internal derangement was popularized by Farrar and McCarty.[16] Research has however shown that condyle position is variable in

From The University of Alberta, Faculty of Dentistry.
This study was funded by the Reyburn McIntyre Fund.
[a]Professor, Division of Orthodontics.
[b]Clinical Instructor, Research Fellow.
[c]Associate Professor, Division of Radiology.
[d]Professor and Chairman, Division of Orthodontics.
Reprint requests to: Dr. Paul Major, Division of Orthodontics, Faculty of Dentistry, University of Alberta, Edmonton, Alberta T6G 2N8, CANADA.

0889-5406/97/$5.00 + 0 **8/1/75236**

both symptomatic and asymptomatic populations and does not accurately predict articular disk position.[17,18] Although posterior condyle position is not diagnostic, symptomatic populations more frequently have a posterior condyle position.[19] The unresolved issue is whether condyle position shifts in response to joint abnormality or whether posterior condyle position predisposes internal derangement.

Several studies have evaluated changes in condyle position with premolar extraction. Luecke and Johnston[6] did not identify a difference in condyle position, by use of cephalometric landmarks, between Class II Div I cases treated with growth modification and cases treated with maxillary premolar extractions. They concluded that changes in condyle position were not correlated with incisor retraction. Artun et al.[11] also compared Class II Div I cases treated with and without premolar extraction. Using sagittal corrected tomograms to identify condyle position after orthodontic treatment, they concluded that extraction of premolars did not result in posterior condyle position. Unfortunately they did not have pretreatment tomograms and therefore could not rule out the possibility that some patients acquired a more posterior condyle position during treatment. They also noted an apparent association between joint sounds and posterior condyle position. Gianelly et al.[20] compared post treatment condyle position in Class II malocclusions treated with maxillary first premolar extraction to pretreatment tomograms of a matched control sample. Condylar position was essentially the same for both groups. In another study Gianelly et al.[21] compared post treatment tomograms between a premolar extraction sample with mixed Class I, Class II Div I, and Class II Div II malocclusions to a matched nonextraction sample. They concluded that premolar extraction was not associated with posteriorly positioned condyles.

Standardized pretreatment and posttreatment temporomandibular joint radiographs should be utilized to truly assess the effect of orthodontic treatment on condyle position. As Tallents et al.[22] stated, "to make an assumption that a condyle has been forced distally as a result of therapy, without appropriate pretreatment documentation, is untenable." A review of the literature concerning effects of premolar extraction on condyle position revealed no articles reporting the use of standardized pretreatment and posttreatment temporomandibular joint radiographs for each subject.

The purpose of this study was to determine the effect of premolar extraction versus nonextraction orthodontic treatment on condyle position in Class I malocclusions by utilizing pretreatment and posttreatment temporomandibular joint tomograms for each patient.

MATERIALS AND METHODS

The sample for this retrospective study was selected from the orthodontic private practice of the principle investigator. All available cases that met the following selection criteria were included:

1. Class I skeletal and dental pattern.
2 Axially corrected pretreatment and posttreatment tomograms were available.
3. No clinical evidence of temporomandibular disorders using the Craniomandibular Index.[23]
4. Centric relation to centric occlusion shift less than 0.5 mm.

All patients were treated with fixed edgewise orthodontics including second molar banding. All 22 patients in the extraction group had extraction of four premolars. Maxillary space closure was completed with "L loop" 0.018 × 0.025 SS closing arch wires in 13 cases and with alastic c-chain on 0.019 × 0.025 SS wire in nine cases. Mandibular extraction spaces were closed with alastic c-chains in all cases. The nonextraction sample included 13 cases. Class II elastics were used in extraction and nonextraction cases as necessary to improve intercuspation. All cases were finished with 0.019 × 0.025 SS archwires. The average length of orthodontic treatment was 25 months for extraction and 21 months for nonextraction groups.

Pretreatment and posttreatment tomographic surveys were obtained with a Tomax machine (Incubation Industries, Inc.) using multidirectional motion. Before tomography, the mediolateral long axis and center of each condyle was determined from a submentovertex projection. Three 2 mm thick corrected-view tomographic slices in the sagittal plane, perpendicular to the mediolateral axis of the right and left condyles, were obtained for each patient postured in maximum intercuspation.

During imaging, static head position was maintained with a cephalostat such that the ala-tragus line was horizontal and parallel to the superior film margin. Pretreatment tomograms were taken within 1 month before initiation of orthodontic treatment, and posttreatment tomograms were taken at the initiation of retention. Fig. 1 shows a tomogram representative of those used in this study.

Tomographic images were coded to allow randomization and blinding of joint space measurements. Each image was traced on separate days and in random order, three times onto acetate overlays with a 0.3 mm diameter lead pencil. All acetate tracings were photocopied three times onto paper hard copies before drafting of reference planes. The horizontal reference plane defined by the superior glenoid fossa tangent, parallel to the superior film border, was assumed parallel to Frankfort horizontal. A line drawn perpendicular to the horizontal tangent line was used to divide the joint space into anterior and posterior halves. Anterior and posterior condylar tangent lines were drawn to intersect with the perpendicular line. Lines perpendicular to the condylar tangent lines were

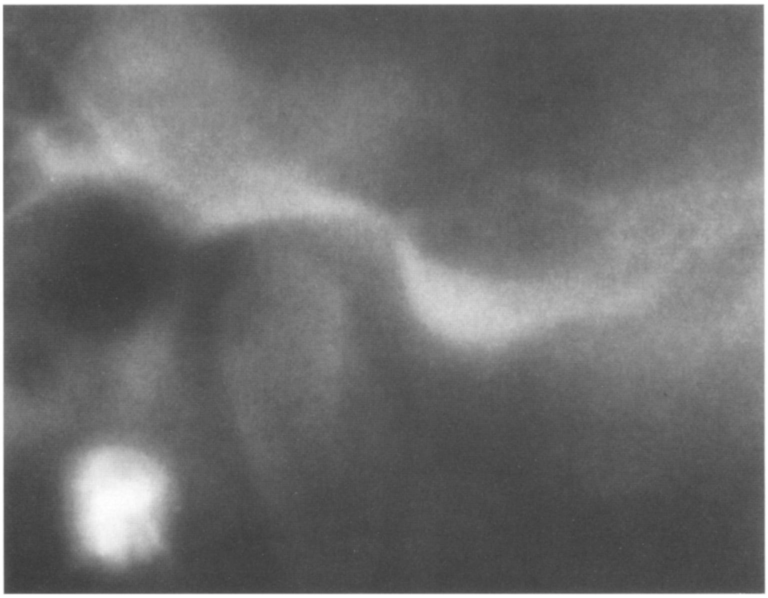

Fig. 1. A representative tomogram.

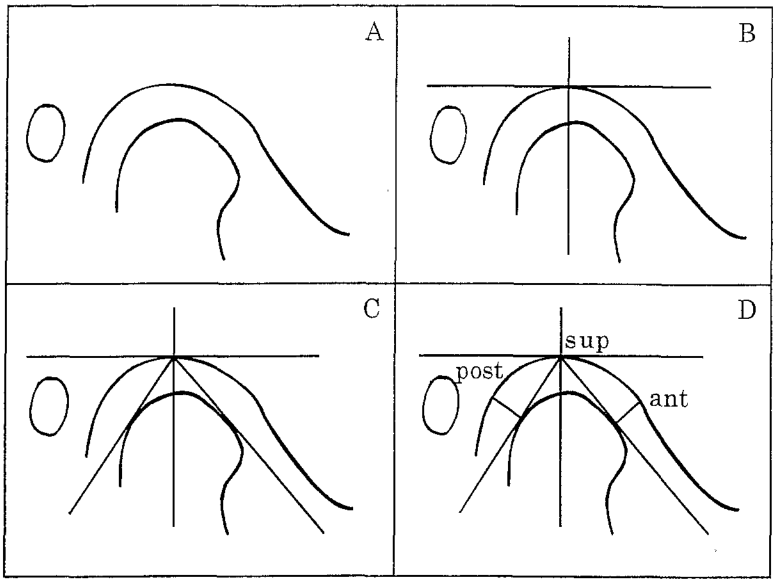

Fig. 2. Drafting on medial, central, and lateral tomographic acetate tracings of each joint. **A,** Pencil tracing (0.3 mm lead) on acetate overlay; **B,** reference plane defined by tangent to glenoid fossa; **C,** anterior and posterior condylar tangents defined by intersection at superior fossa; and **D,** linear measurement perpendicular to tangential intersections.

used to measure joint space width. Linear joint spaces were defined as posterior, superior, and anterior (Fig. 2). Joint spaces were randomly measured three times on each photocopy by use of Mitutoyo (Mitutoyo Canada, Inc.) digital read out calipers capable of displaying 0.01 millimeter. A total of 27 measurements of the anterior, superior, and posterior joint spaces were obtained from each tomogram and averaged.

Descriptive statistics were determined for each group of subjects for age, gender, length of treatment, and duration of Class II elastic wear. Comparisons of pretreatment and posttreatment joint spaces between groups were done by t test (pooled variance estimate) at $p < 0.05$. Correlations between mean differences in pretrearment and postreatment joint spaces and length of elastic wear were also determined.

Table I. Sample distribution

Group	N	Male	Female	Mean/age (range)	Months of Class II elastic wear
Extraction	22	12	10	17.1 (14-34)	5.03 + 4.23
Nonextraction	13	4	9	18.7 (14-33)	3.15 + 3.15

Table II. Anterior joint space (mm)

	Pretreatment		Posttreatment	
Group	Mean	SD	Mean	SD
Extraction				
Left	2.17	0.88	2.31	0.87
Right	1.89	0.75	2.10	0.85
Nonextraction				
Left	1.83	0.69	2.32	0.88
Right	2.01	0.88	2.40	1.09

Table III. Superior joint space (mm)

	Pretreatment		Posttreatment	
Group	Mean	SD	Mean	SD
Extraction				
Left	3.34	1.15	3.22	1.11
Right	3.31	1.29	3.21	1.10
Nonextraction				
Left	3.12	0.78	3.12	0.97
Right	3.39	0.72	3.63	0.73

RESULTS

Pretreatment and posttreatment mean joint space measurements for extraction and nonextraction groups are reported (Tables II through IV). Pretreatment joint spaces were not significantly different between groups. Posttreatment joint spaces were also not significantly different between groups.

Left and right anterior joint space was significantly increased during orthodontic treatment of the nonextraction group. No other significant changes in condyle position were determined in either group.

There were no significant correlations between mean change in joint space before and after treatment with the length of elastic wear for the extraction group, nonextraction group, and the combined groups. There was no significant difference in condyle position change associated with space closure with closing arch wires compared with space closure with elastic chain on rectangular wire.

Table IV. Posterior joint space (mm)

	Pretreatment		Posttreatment	
Group	Mean	SD	Mean	SD
Extraction				
Left	2.38	0.73	2.45	0.89
Right	2.56	0.98	2.51	0.89
Nonextraction				
Left	2.41	0.78	2.49	0.77
Right	2.49	0.84	2.65	0.76

Table V. Mean change in joint space

	Anterior		Superior		Posterior	
Group	Mean	SD	Mean	SD	Mean	SD
Extraction						
Left	0.13	0.94	−0.21	0.95	0.07	0.91
Right	0.21	0.72	−0.10	1.00	−0.05	0.97
Nonextraction						
Left	0.49*	0.74	−0.01	0.81	0.08	0.89
Right	0.39*	0.77	0.24	0.77	0.16	0.87

*Significant at $p < 0.05$.

DISCUSSION

The etiology of temporomandibular disorders and, in particular, internal derangement is poorly understood and controversial. Literature generally supports an increased frequency of posterior condyle displacement in patients with internal derangement, but joint space analysis is not a valid predictor of disk position.[17,18] With the relatively high cross-patient variability in osseous spatial relationships in adult populations, many researchers and clinicians consider condyle position an issue of minor importance. Until longitudinal studies of asymptomatic patients are conducted, the importance of condyle position in the pathogenesis of joint disorders will remain unknown. The hypothesis that condylar retrusion represents a risk factor, through altered biomechanics or impingement of the bilaminar zone that maintains blood flow and nutrition in the joint, is still an important consideration. Until research identifies the level of risk (if any), it is prudent for orthodontists to identify the treatment modalities that result in condyle displacement.

To our knowledge, this is the first study utilizing pretreatment and posttreatment corrected tomograms to assess condyle displacement during routine orthodontic treatment. All previous studies compared joint space measurements or joint space ratios taken after treatment with a separate control sample. Individual variability in condyle position is well-documented in the literature and necessitates large sample sizes for comparing average condyle positions between study groups. Using pretreatment and posttreatment joint space measurements on the same patient population in this study allows a more sensitive assessment of condyle displacement. A similar approach has been utilized to assess condyle position changes associated with orthognathic surgery.[24-27]

Direct comparison of condyle position with pretreatment and posttreatment tomograms does have limitations. The Tomax machine utilized in this study uses hypocycloidal motion with excellent image clarity. Head position was controlled with a cephalostat. The same machine settings for tomograph depth of cut and slice angulation were used to obtain pretreatment and posttreatment radiographs. A central tomographic slice was utilized to minimize the effect of condyle rotation around a vertical axis on joint space measurements. Unfortunately reproducibility of joint space measurement on repeated exposures of the same person is not known. Variations in head position within the cephalostat will, at least to some degree, affect depth of cut and slice angulation. The literature suggests that head rotation within a cephalostat greater than five degrees is clinically detectable and can be controlled.[28] Kamelchuk and Major[29] have reported that 10-degree rotation about the transverse plane does not affect joint space measurements. For this reason, possible variations in head position likely did not affect our results. The effect of head position on depth of cut is not known. Joint space dimensions are not consistent in the lateral, central, and medial portions of the joint[30] and therefore variation in depth of cut may affect reproducibility. The mean age for this sample was 17 to 18 years, with some patients still completing growth. The effect of growth on condyle position has not been reported. Notwithstanding these limitations utilization of pretreatment and posttreatment images in this study to assess condyle displacement is superior to previous studies.

To isolate the specific effect of premolar extraction in orthodontic treatment on condyle displacement, the number of treatment variables were reduced. All cases were asymptomatic, Class I skeletal and dental malocclusions with minimal functional centric relation to centric occlusion shift. Treatment mechanics were limited to two techniques for space closure. Previous studies utilized largely Class II samples or mixed Class II and Class I samples. A variety of mechanics by a number of different operators were also used in previous studies, reducing the value of their findings.

This study found a significant increase in anterior joint space dimension in nonextraction cases and no joint space change in extraction cases.

Because posterior joint space was not affected, it is unlikely that increased joint space in the nonextraction sample was caused by anterior condyle movement. Anterior joint space could be altered independent of posterior joint space if the condyle was rotated as a result of a change in vertical dimension of occlusion. Staggers[14] however reported no significant difference in the amount of vertical dimension change in extraction versus nonextraction treatment. Anterior joint space is also potentially affected by articular surface remodelling of both the condyle and articular eminence. This would imply different adaptive response to joint loading between extraction and nonextraction orthodontic treatment. Although statistically significant, a mean increase in joint space of approximately 0.39 to 0.49 mm is not likely clinically significant. The temporomandibular joints are capable of adaptive remodelling, and condyle displacements of similar magnitudes have been identified during static clenching.[31] Orthodontic treatment induces a continual series of neuromuscular and/or skeletal adaptive changes. Only if the adaptive threshold is exceeded will the patient develop dysfunction.

Sample size available for this study was small and caution should be exercised in interpreting the results. Additional studies utilizing larger samples are needed to further evaluate the effect of orthodontic treatment mechanics on temporomandibular joint anatomic relationships.

CONCLUSION

Nonextraction fixed orthodontic treatment of Class I malocclusion resulted in a small but statistically significant increase in anterior joint space. Premolar extraction and fixed orthodontic treatment of Class I malocclusion did not result in a significant change in condyle position. Length of elastic wear was not correlated with condyle position change.

We thank Drs. E. Diduch, V. McMullen, and J. Field for their assistance.

REFERENCES

1. O'Connor B. Contemporary trends in orthodontic practice. A national survey. Am J Orthod Dentofac Orthop 1993;103:163-70.
2. Reynders M. Orthodontics and temporomandibular disorders. A review of the literature (1996-1988). Am J Orthod Dentofac Orthop 1990;97:463-71.
3. Sadowsky C, Bebole EA. Long term status of temporomandibular joint function

and functional occlusion after orthodontic treatment. Am J Orthod 1980;78: 201-12.
4. Sadowsky C, Polson AM. Temporomandibular joint disorders and long term occlusion after orthodontic treatment. Results of two long term studies. Am J Orthod 1984;86:386-90.
5. Dibbets JMH, van der Weele LT. Orthodontic treatment in relation to symptoms attributed to dysfunction of the temporomandibular joint. A 10 year report of the University of Groningen study. Am J Orthod Dentofac Orthop 1987;91:193-205.
6. Luecke PE, Johnston LE. The effect of maxillary first premolar extraction and incisor retraction on mandibular position. Testing the central dogma of "functional orthodontics." Am J Orthod Dentofac Orthop 1992;101:4-12.
7. Egermark I, Thilander B. Craniomandibular disorders with special reference to orthodontic treatment. An evaluation from childhood to adulthood. Am J Orthod Dentofac Orthop 1992;101:28-34.
8. Rendell JK, Norton LA, Gay T. Orthodontic treatment and temporomandibular joint disorders. Am J Dentofac Orthop 1992;101:84-7.
9. Kremenak CR, Kinser DD, Harman HA, Menard CC, Jakobbsen JR. Orthodontic risk factors for temporomandibular disorders (TMD). I. Premolar extractions. Am J Orthod Dentofac Orthop 1992;101:13-20.
10. Hirata RH, Heft MW, Hernandez B, King GL. Longitudinal study of signs of temporomandibular disorders (TMD) in orthodontically treated and non treated groups. Am J Orthod Dentofac Orthop 1991;101:35-40.
11. Artun J, Hollender LG Truelove EL. Relationship between orthodontic treatment, condylar position, and internal derangement of the temporomandibular joint. Am J Orthod Dentofac Orthop 1992;101:48-53.
12. Witzig JW, Spahl TJ. The clinical management of basic maxillofacial orthopedic appliances. Littleton (MA):PSG Publishing, 1987:161-216.
13. Bowbeer GR. The sixth key to facial beauty and TMJ health. Function Orthod 1887;4:4-22.
14. Staggers JA. Vertical changes following first premolar extractions. Am J Orthod Dentofac Orthop 1994;105:19-24.
15. Levy PH. Clinical implications of mandibular repositioning and the concept of an alterable centric relation. Int J Orthod 1979;17:6-25.
16. Farrar WB, McCarty WL. A clinical outline of temporomandibular joint diagnosis and treatment. Montgomery (AL): Walker, 1983;84-5.
17. Kassebaum DK, McDowell JD. Tomography. Radiology 1993;37:567-74.
18. Brand JW, Whinery JG Jr, Anderson QN, Keenan KM. Condyle position as an indicator of temporomandibular joint internal derangement. Oral Surg Oral Med Oral Pathol 1989;67:469-76.
19. Ronquillo HI, Guay J, Tallents RH, Katzberg RW, Murphy W. Tomographic analyses of mandibular condyle position as compared to arthrographic findings of the temporomandibular joint. J Craniomand Disorder 1988;2:59-64.
20. Gianelly AA, Cozzani M, Boffa J. Condylar position and maxillary first premolar extraction. Am J Orthod Dentofac Orthop 1991;99:473-6.
21. Gianelly AA, Hughes HM, Wohlgemuth P, Gildea G. Condylar position and extraction treatment. Am J Orthod Dentofac Orthop 1988;93:201-5.
22. Tallents RH, Catania J, Sommers E. Temporomandibular joint findings in pediatric populations and young adults. A critical review. Angle Ortho 1990; 61:7-15.
23. Fricton JR, Schiffman EL. The craniomandibular index: validity. J Prosthet Dent 1987;58:222-8.
24. Athanasion AE, Marreas D. Tomographic assessment of alterations of the temporomandibular joint after correction of mandibular prognathism. Int J Adult Ortho Orthognath Surg 1991;6:105-12.
25. Hackney FL, VanSickeles JE, Nummikoski PV. Condylar displacement and temporomandibular joint dysfunction following bilateral sagittal split osteotomy and rigid fixation. J Oral Maxillofac Surg 1989;47:223-37.
26. Mavreas D, Athanasion AE. Tomographic assessment of alterations of the temporomandibular joint after surgery. Eur J Orthod 1991;14:3-15.
27. Petterson A, Willmar-Hogeman K. Radiographic changes of the TM joint after oblique sliding osteotomy of the mandibular rami. J Oral Maxillof Surg 1989;18: 27-31.
28. Alhquist J, Eliasson S, Welander V. The effect of head projection errors on cephalometric length measurements. Eur J Orthod 1986;8:141-8.
29. Kamelchuk LS, Grace M, Major PW. Post-imaging temporomandibular joint space analysis. J Craniomandib Pract 1996;14:23-9.
30. Hatcher DC, Blom RJ, Baker CG. Temporomandibular joint spatial relationships. Osseous and soft tissues. J Prosthet Dent 1986;56:344-53.
31. Ito T, Gibbs CH, Marguelles-Bonnet R, Lupkiewicz SM, Young HM, Lundeen HC, Mahan PE. Loading on the temporomandibular joints with five occlusal conditions. J Prosthet Dent 1986;56:478-84.